TERRASOND®

PRECISION GEOSPATIAL SOLUTIONS®

Survey Plan
Jorgensen Forge Early Action
Duwamish River, Seattle, Washington

March 4, 2014

Prepared for:

Pacific
Pile&Marine

Submitted by:

TerraSond Limited

801 NW 42nd Street, Suite 215
Seattle, Washington 98107 USA
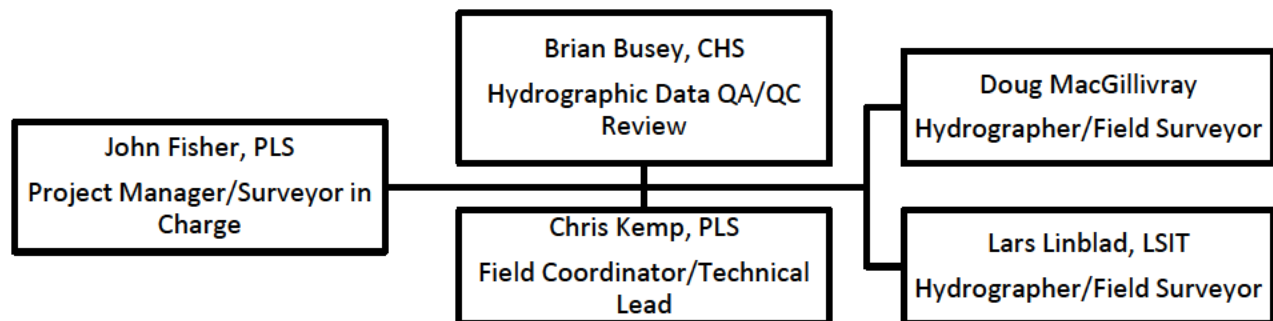Phone: +1 (206) 420-8304
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Description of Work

The project is located on the Duwamish River at 8531 East Marginal Way. The project includes collection of multibeam hydrographic survey data within the project survey area as shown on sheet C-1 of the bid plan set as well as upland topographic surveys. TerraSond will be performing the hydrographic and topographic surveys on behalf of Pacific Pile and Marine (PPM) as defined in section 017123 – 1.04 and 1.05.

Hydrographic surveys will be conducted in accordance with the USACE Hydrographic Survey Manual EM 1110-2-1003. Topographic surveys will be conducted in accordance with the laws of the State of Washington and in reference to USACE Engineering and Design Control Topographic Survey manual EM1110-1-1005.

Personnel – Bathymetric and Topographic Survey Organization Chart

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                    ┌──────────────────────────┐
                    │    Brian Busey, CHS       │        ┌──────────────────────────┐
                    │  Hydrographic Data QA/QC  │        │   Doug MacGillivray       │
                    │         Review            │        │ Hydrographer/Field Surveyor│
┌────────────────┐  └──────────────────────────┘        └──────────────────────────┘
│ John Fisher, PLS │
│ Project Manager/ │
│ Surveyor in      │  ┌──────────────────────────┐        ┌──────────────────────────┐
│ Charge           │  │    Chris Kemp, PLS        │        │   Lars Linblad, LSIT      │
└────────────────┘  │ Field Coordinator/Technical│        │ Hydrographer/Field Surveyor│
                    │          Lead             │        └──────────────────────────┘
                    └──────────────────────────┘
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The TerraSond project office is located in Seattle at 801 NW 42nd Street, Suite 215, Seattle, WA 98107. Field and office staff will operate out of this office.

Contact information:

John Fisher:	Office: 206-420-8304	Mobile	(b) (6)
Brian Busey:	Office: 206-420-8304	Mobile	
Chris Kemp:	Office: 206-420-8304	Mobile	
Doug MacGillivray:	Office: 206-420-8304	Mobile	
Lars Lindblad:	Office: 206-420-8304	Mobile	

Resumes for project staff are attached at the end of the survey plan.

Coordination – Pre Project Planning

The PPM project manager and TerraSond project manager will coordinate the survey activities. The TerraSond PM and field hydrographer will be dedicated to the project and TerraSond will maintain the hydrographer on-site for the duration of field activities, approximately 45 days. A planning meeting between PPM, TerraSond, and Engineer will be scheduled to review, clarify, and finalize any design changes, schedule, or requirements.
Before field activities begin, TerraSond will calibrate and check the PPM excavator, review and verify survey control, and establish tide board and tide gauge.

Surveys to be Performed by Terrasond

Per section 017123 TerraSond will perform the following multibeam/topographic surveys.

- Pre-Construction Baseline Survey
- Final Dredging Acceptance by DMU
- Final JFOS Impacted Material Area Acceptance
- Final Backfill Acceptance
- Final Filter Acceptance
- Final Riprap Acceptance
- Final As-Built Survey

Terrasond will perform the following uplands topographic surveys

- Removal stockpile survey
- Post-Replacement stockpile survey

In addition, TerraSond will maintain a hydrographer/surveyor on-site for the duration of dredging operations to perform progress surveys as needed by PPM to check and verify dredge depths as detailed in section 017123-3.07.

Work area is shown below.
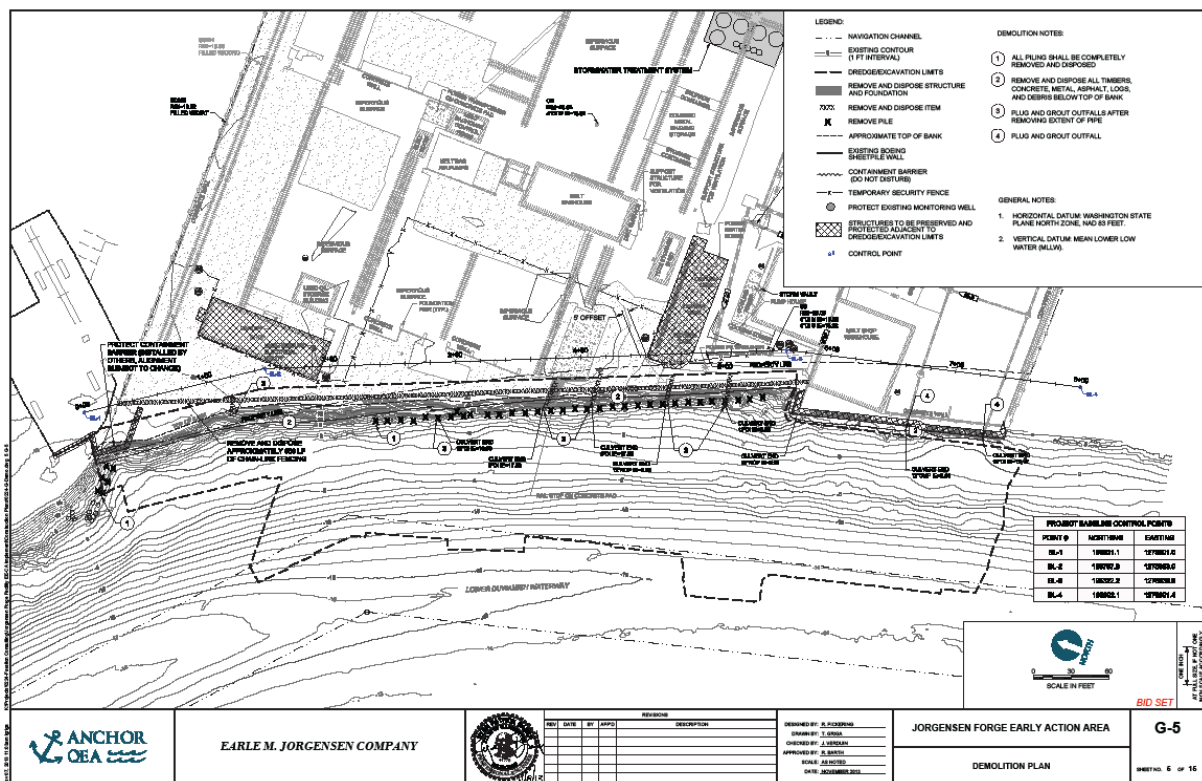
Project Safety

All personnel will be supplied with necessary personal protective equipment relevant to the activities undertaken. This will include, but not be limited to, personal flotation devices, work vests, gloves, and eye protection. Safety boots are used where necessary, but are not normally worn routinely on-board survey vessels.

The table below identifies potential activity risks for this project and control measures.

Table 1 – Identified Activity Hazards and Risks

Hazards/Risk Identified	Control Measures	Mob/Demob survey	Travel by truck to/from the survey	Bathymetric Survey	Reference
Drugs and alcohol	• No person should report to work if unfit to do so • The possession or use of drugs or alcohol at work is forbidden	X	X	X	TerraSond D&A Policy
Vehicle collision (Driver/vehicle factors)	• Appropriate speed • Driver anticipation • Maintaining state separation distance • Always use mirrors, and signal clearly before maneuvering • Defensive driving techniques		X		
Trailer sway/jack-knife	• Correctly loaded trailer and tongue weight • Appropriate speed in corners and bends • Do not brake • Wheel and tire conditions (tread, pressure, wheel nut torque)	X	X		
Personal injury while using hand and power tools	• Use gloves and eye protection where appropriate • Use correct tools in good condition • Make sure electrical connections and extension leads are in good condition.	X		X	
Personal injury while lifting or launching equipment	• Two people to lift loads over 50 pounds (23 kg) • Use safe lifting techniques • Used mechanical winch to retrieve equipment	X		X	
Entanglement in lines and cables	• Store lines, ropes and instrument cables off the deck • Do not put feet inside coils of cable or the bite of ropes • Do not wrap lines and cables around hands, arms or body particularly those used for towing instruments • Use suitable gloves to aid grip and prevent rope burns	X		X	
Man overboard, slips, trips and falls on deck	• Use boots/shoes with non slip soles • Used handholds and rails to maintain three points of contact then moving around the vessel • Wear personal flotation device when working outside the wheel/instrument house			X	
Gasoline and diesel (refueling vessel and portable equipment)	• Use approved robust containers • Switch off and cool engine before refueling • Use hose and/or funnel and spill prevention measures • Fire extinguisher must be available on a vessel or inside a building	X		X	

Significant activity hazards and risks relevant to this work that should be briefed to the workforce are identified above. Routine safety measures are covered by personal competence, supervision and training.

The table below identifies potential site risks for this project and control measures.

Table 2 – Identified Site Hazards and Risks

Hazards/Risk Identified	Control Measures	Mob/Demob survey equipment	Travel by truck to and from the survey	Bathymetric or Topographic Survey	Reference
Vehicle collision (other road users)	• Regulate the speed to always maintained the ability to stop if lane obstructed (particularly when towing) • Anticipate the movements of other road users and make allowances • Give way to other road users courteously • Defensive driving techniques		X		
Working in and around construction/dredge equipment	• Keep eye contact with operators to alert them of your presence. • Be alert for rapidly changing conditions.			X	
Vessel collision with marine traffic	• Maintain a continual watch for other shipping • Coordinate survey with movements of shipping • Follow shipping lanes obey speed limits • Give way to vessels that right of way or are restricted in manoeuvrability • Maintain a radio watch on marine frequencies			X	
Emersion causing anoxia or hyperthermia (Man overboard)	• Wear a personal floatation device when working on deck or over the water • Launch a life buoy and line and maintain a continuous watch on the person in the water • All personnel reminded of abandon ship arrangements before work begins			X	
Slips, trips, falls on rocks and on the shore line	• Do not rush make a steady measured pace when walking • Use boots with non slip soles • Use boots with ankle support on rocky surface • Avoid steep slopes and stepping on rocks covered in algae or seaweed • when using steps or stairs use the hand rail where provided				
Significant site hazards and risks relevant to this work that should be briefed to the workforce are identified above. Routine safety measures are covered by personal competence, supervision and training.					

A project safety meeting will be held at the beginning of each survey day.

Survey Control

Project survey control will be as provided by the Project Engineer.

Project datums are as follows:

Horizontal Datum: NAD83, Washington State Plane, North Zone, US Survey Feet

Vertical Datum: MLLW (NOS) Epoch 83-01

Survey Equipment

The table below identifies survey equipment to be used on this project. Full specifications are attached.

Table 3 – Survey Equipment

Component	Model	Description
Multibeam Echosounder	Reson SeaBat 7125	200-400 kHz multibeam, 0.5 degree beamwidth, max 165 degree swath.
Inertial Navigation System/RTK Positioning	Applanix POS MV	Position, heave, pitch, roll and heading sensor.
RTK Positioning	Topcon Hiper V / Trimble SPS	Dual frequency, low-latency base and rover GPS receivers.
Total Station	Leica TPS 1200	1" Angle Accuracy, 1mm + 1.5 ppm distance accuracy
Acquisition Software	HYPACK 2013	Hydrographic data acquisition and navigation software.
Processing Software	Caris Hips 7.1	Hydrographic data cleaning and processing software.
Sound Velocity Profiler	AML SVPlus	Internal recording, 500dBar instrument for measuring sound velocity profiles.
Tide Gauge	DAA 500 XL	High resolution data logger capable of telemetry communications
CADD Software	ACAD Civil 3d 2013	Drafting Software.

Vessel

The vessel to be used in the survey is the *R/V FogDog*, a 27-foot Alamar, shallow draft, aluminum survey platform with jet drive. The vessel is equipped with an over-the-side multibeam pole mount. The mount swings the pole outboard to deploy the sonar. The pole is bolted into place during the survey. The vessel has dual displays for the operator and survey tech, inverter, extra-large battery bank and auxiliary generator for ample power capacity. The vessel also has on-board cellular Internet and Wi-Fi connectivity so that trouble shooting can be done remotely.

The inertial navigation system used for the survey is an Applanix POS MV. The POS MV consists of a motion reference unit (MRU) coupled with two GPS receivers. The MRU is rigidly mounted near the vessel center of gravity and the antennas are mounted port and starboard on the forward cabin roof. The POS MV outputs RTK position, heading, heave, pitch and roll.

Figure 1 – *R/V FogDog*

Topographic Survey Methodology

Topographic surveys will be performed primarily using RTK GPS as much as possible and conform to the specifications as outlined in section 017123-3.04-B.

Hydrographic Survey Methodology

Hydrographic surveys will be performed from the *RV Fogdog*. Survey procedures will conform to specifications as outlined in section 017123-3.04-C. The *Fogdog* is equipped with a Reson 7125 multibeam capable of 0.5 degree beam widths and the Applanix POS MV IMU. GPS RTK broadcast from project control will be used for vessel positioning. HYPACK 2013 will be used for field data collection of multibeam sonar data.

A tide board will be established on site for visual monitoring as needed. In addition, a DAA 500 XL series or similar strain gauge will be established with telemetry to broadcast tide readings to the dredge or other vessels as needed.

Pre-Survey Checks

Prior to and during data collection, a series of quality assurance checks will be conducted to verify the sounding accuracies. The checks that will be conducted include:

1. Control Check
2. Positioning System Check
3. Water Surface Check
4. Bar Check
5. Patch Tests

- **Control Check**
  After the RTK base station is set-up, a check shot will be made on secondary control to verify base station coordinates and instrument heights.

- **Positioning System Check**
  This check is performed to verify the accuracy of the vessel positioning system. A comparison will be conducted between the vessel position from the POS MV and an independent RTK GPS, both in RTK mode receiving corrections from the same base.

- **Water Surface Monitoring**
  RTK GPS will be used to monitor the water level during survey and correct the soundings to the project datum. The RTK accuracy will be checked by recording RTK water surface elevations on the vessel while simultaneously reading the tide gauge board installed at the project site.

- **Patch Test**
  A patch test is a set of systematic lines that are run to determine the alignment errors between the motion reference unit and the multibeam. A patch test will be conducted at the beginning of the project. Roll, pitch, yaw and latency patch lines will be run and biases determined using the CARIS HIPS calibration utility.

Sound velocity cast will be taken at the beginning of each day and at approximately a two-hour interval throughout the day. Sound velocity profiles will be used to correct soundings for time-of-flight and beam refraction in post processing.

Processing Procedure

Multibeam data will be processed using CARIS HIPS version 7.1. HIPS provides data processing tools that can take all of the raw sensor data recorded during data acquisition and create a final sounding set. The general HIPS workflow is composed of the following steps:

1. Data Conversion. Raw data is converted from the native HYPACK format to a HIPS format.

2. Sensor Editing. Sensor data such as heave, pitch, roll and navigation is reviewed. The data can be edited for spikes, smoothed, interpolated or rejected if necessary.

3. Sound Velocity Processing. Sound velocity processing converts the soundings from raw beam angle and time of flight measurements to soundings based on the sound velocity profile of the water column and vessel attitude measurements. Vessel offset parameters computed from patch test results and vessel surveys are applied during this step.

4. Swath Editing. Soundings from individual lines are cleaned in the swath editor. The swath editor allows the hydrographer to examine and reject erroneous data and filter lines based on swath limits.

5. Merging. Water level and other vertical corrections are applied to the soundings. The soundings are converted from time, beam and ping format referenced to the vessel location, to a fully geo-reregistered sounding.

6. Subset Editing. Subset editing is the final step in the data cleaning process. The subset editor allows the hydrographer to view data from multiple survey lines in a region in a single 2D and 3D spatial editor.

7. Surface Processing. After the data has been cleaned and finalized, HIPS creates a gridded surface from the data called a base surface. The horizontal resolution of the surface is user specified and depends on the resolution of the acquired data and the accuracy requirements.

General Survey Workflow

The pre-construction baseline topographic and multibeam survey will be performed at least 5 days prior to dredging or excavating activities in accordance with Section 017123-3.06-A.

Progress surveys will take place during material removal daily at minimum and delivered electronically to the Engineer within a 24 hour period. Surveys will be of a generally small size and processed the same day as the survey or the following day either on site or at TerraSond's office in Seattle. Survey data will be reviewed by a PLS or CHS as needed. CADD sheet cuts will be prepared prior to progress surveys begin, so that data can be imported into CADD and delivered quickly to the Engineer. TerraSond will stay in close contact with PPM and Engineer throughout operations and notify either to resolve issues or answer questions.

Final DMU acceptance surveys, JFOS survey, Backfill Surveys, Filter Surveys, Riprap Surveys, Stockpile Surveys will be conducted in similar manner or as specified in Section 017123-3.04 6E 2-8.

The Final As-Built Survey will be prepared in ACAD Civil 3D version 2013 in accordance with Section 017123-3.08.

It is understood that the Engineer may accompany the survey crew during any or all of these surveys.

Positioning Control for Dredging Operations

Pacific Pile & Marine's EX1200 excavator is equipped with servos on the boom and on-board monitors and computer operating HYPACK DREDGEPACK software. The bucket position will be continuously monitored through DREDGEPACK. Templates are loaded into the software which allows the operator to excavate to design limits while also monitoring heading and bucket positioning. TerraSond hydrographic technicians will check and calibrate the bucket positioning system before dredge operations begin. During dredge operations, the excavator will be equipped with Internet capability allowing TerraSond personnel to connect to the on-board computer to assist the operator, or upload revised templates or design limits. Additional sensors and or on board dredge computers will be available should any system malfunction during operations. Every effort will be made to make certain all systems are operational and calibrated before dredging or excavation begins.

Servos mounted in daisy chain orientation shown below.

GPS antennas mounted on rear of EX1200 provide positioning and direction.

Before site work begins, the TerraSond Project Manager will attend a kick-off meeting with the Project Engineer and Contractor to discuss methodologies, procedures and deliverables.

Spec sheets and calibration reports for equipment follow.

WATERLOG® SERIES

Model H-500XL™
Data Collection Platform (DCP)

The *WATER*LOG® Model H-500XL™ is a data logger designed for remote operation. This instrument can be interfaced with:

- Other Data Loggers
- GOES Transmitter
- Remote Displays
- Telemetry Systems
- Modems
- Variety of Sensors

KEY FEATURES

- Ideal for small Hydrologic/Met Stations
- Built-in key pad and easy-to-read display can be used for complete system configuration or to view measured values
- External button allows simplified means to view current data values
- Three RS-232 Serial Ports for use with local terminals, modems, GOES Radios, remote displays, etc.
- Four analog inputs
- SDI-12 Master mode

- Two programmable digital inputs/outputs
- One event counter input (Tipping Bucket Rain Gauge)
- Frequency input (wind speed)
- Quadrature shaft encoder input
- Scalable and programmable 4-20 mA Output
- Data logging capability using nonvolatile internal storage (4 Meg and up)
- Sealed, corrosion-resistant, nonconductive enclosure
- Operating temperature range of -40° to 60°C

SPECIFICATIONS

Performance
General Analog Input
Channels:	4 (Single Ended)
Ranges:	Programmable (Channel 1 Only)
Resolution:	16-Bit Resolution (1 Part in 65536)
Accuracy:	±0.02% FS
Input Ranges:	0 to 5 Volts (All Channels)
	0 to 500 mV (Additional Input Range Only Available on Channel 1)
	Accuracy ± 0.15%

Excitation   5.0V Switched, Ratiometric with 10mA (max load)

Accuracy   ± 1.0 mV Over Load and Temperature Range

Frequency Input
Input Range:	1-10 KHz at ±75mVolts or greater
	1-15 KHz at ±1Volt or greater
Input Amplitude:	± 5.0 Max
Accuracy:	± 0.1%
Resolution:	1/10000 * Reading

Counter Input
Type:	Switch closure or voltage pulse, Internal 50k pull up resistor, falling edge triggered.
Input Voltage:	0-5 Volts
Minimum Pulse Width:	5 mS
Input Frequency:	100Hz (max)

Digital I/O
Channels:	2, Independently configured for input or output
Input Voltage:	0-5 Volt
High Level:	3.5 V (min)
Low Level:	0.8 V (max)

Output Voltage
Low:	0.4 V (max)@ -5mA
High:	3.5 V (min)@+5mA

4-20 mA Output
Resolution:	4.0 A

Data Storage
Type:	Non-Volatile FLASH
Size:	4 Mega Byte Minimum (Expandable)

Interface
SDI-12
	SDI-12 Master Mode
Protocol:	SDI-12, 7-bit even parity, 1 stop bit
Baud Rate:	1200

RS-232
	RS-232 Communication Ports
Protocol:	RS-232, 8-bit, no parity, 1 stop bit
Baud Rate:	Programmable

Mechanical Data
Physical
Enclosure:	Sealed, corrosion resistant fiberglass with clear Lexan® window
Size:	7.0 in. wide x 8.5 in. long x 4.3 in. deep
Weight:	4.25 lbs.
Mounting:	Hardware supplied for wall mounting

Power
Input Voltage:	10.0 to 16.0 Volts	
Input Current:	Sleep Mode:	4mA typical
	Active:	80 mA average (measuring, display off)
	Active:	250mA average (measuring, display on)
	Auto display shut-off after 5 minutes	

Environment
Temperature
Extended Operating Range:	-40 to 60 C
Storage:	-40 to 80 C

Humidity	0-95% non-condensing

Miscellaneous
Options
Data Logging:	Data is stored internally to Nonvolatile Memory
GOES:	H-222-SE (Signal Engineering) or H-222 (Telonics)

Accessories (Supplied)
Cables/Connector: - 9-pin D connector cable required for RS-232 communication available (H-350-RSC)
- 9-pin D Male to Male Gender Changer
- RS-232 Null Modem Adaptor
- Sensor Terminal Block

Warranty
The *WATERLOG*® H-500XL™ is warranted against defects in materials and workmanship for one year from date of shipment.

Note
Specifications subject to change without prior notice due to ongoing commitment to product testing and improvement. LR June 18, 2003

Certificate of Calibration

This certifies that your precision instrument met all of the specifications determined by tests performed on the date listed below. This instrument was subjected to extensive pre-qualifications. It was then calibrated using an automated test system over a period of approximately 20 hours followed by another 20 hour validation test.

WaterLOG calibration standards are traceable to the National Institute of Standards and Technology (NIST). The Model Number and Serial Number of the standard used are listed below.

The test data below is a sampling of the 150 actual data points taken during the pre-shipment validation test on this instrument.

Tested by

TEST REPORT

REPORT DATE: 04/11/2013
DATE TESTED: 04/10/2013
MODEL NUMBER: H350XL
SERIAL NUMBER: S#001050
NIST TRACEABLE REFERENCE: DH INSTRUMENTS, INC PPC4 us A700K   Ver1.01a
Serial #414

Reference Temp.	Measured Temp	Reference Press.	Measured Press.	Delta
-40.1	-40.2	0.000	-0.001	0.001
-40.0	-40.1	4.588	4.588	0.000
-40.0	-40.0	9.081	9.080	0.001
-40.0	-40.0	18.065	18.065	0.000
-40.0	-40.0	27.053	27.051	0.002
-29.9	-30.3	1.547	1.548	-0.001
-30.1	-30.2	6.087	6.087	0.000
-29.9	-30.2	12.075	12.073	0.002
-30.1	-30.2	21.063	21.060	0.003
-29.9	-30.2	30.199	30.195	0.004
-20.1	-20.1	3.087	3.087	0.000
-20.1	-20.0	7.586	7.586	0.000
-20.1	-20.0	15.074	15.073	0.001
-19.9	-20.0	24.060	24.060	0.000
-10.1	-10.2	0.000	-0.002	0.002
-9.8	-10.1	4.589	4.587	0.002
-10.0	-10.1	9.083	9.082	0.001

Reference Temp.	Measured Temp	Reference Press.	Measured Press.	Delta
-10.0	-10.1	18.066	18.067	-0.001
-10.0	-10.1	27.056	27.055	0.001
0.1	-0.2	1.571	1.572	-0.001
0.1	-0.2	6.086	6.086	0.000
-0.1	-0.1	12.077	12.075	0.002
0.1	-0.1	21.063	21.063	0.000
0.0	-0.1	30.203	30.203	0.000
10.0	9.9	3.086	3.088	-0.002
10.0	9.9	7.585	7.587	-0.002
9.9	10.0	15.072	15.070	0.002
9.9	10.0	24.059	24.059	0.000
20.0	19.8	0.000	0.000	0.000
19.9	19.9	4.588	4.587	0.001
20.1	20.0	9.083	9.083	0.000
20.0	20.0	18.070	18.071	-0.001
20.0	20.1	27.055	27.055	0.000
29.9	30.0	1.544	1.542	0.002
30.1	30.1	6.085	6.085	0.000
30.0	30.1	12.077	12.076	0.001
30.0	30.1	21.066	21.066	0.000
30.0	30.2	30.199	30.201	-0.002
39.9	40.0	3.086	3.086	0.000
39.9	40.0	7.584	7.584	0.000
39.9	40.1	15.073	15.072	0.001
40.0	40.1	24.058	24.058	0.000
49.9	49.8	0.000	0.001	-0.001
50.0	49.9	4.588	4.588	0.000
50.0	50.0	9.083	9.083	0.000
49.9	50.0	18.069	18.071	-0.002
49.9	50.1	27.055	27.054	0.001
60.0	60.0	1.570	1.569	0.001
60.0	60.1	6.085	6.085	0.000
59.9	60.2	12.075	12.073	0.002
59.8	60.2	21.054	21.054	0.000
60.0	60.2	30.178	30.179	-0.001

Maximum Deviation From Standard: 0.004,   -0.002

SV*PLUS*

Sound Velocity, Temperature, and Depth Profiler

User's Manual

Revision 1.23
April 2005

1 INTRODUCTION

1.1 System Description

The SV^{PLUS} is a multi-parameter, self-contained, intelligent instrument, designed for the measurement of sound velocity, temperature, and pressure.

The SV^{PLUS} features microprocessor based CMOS circuitry, two A/D converters (1 part in 40,000, 1 part in 16,000) and 128 Kbytes of battery backed-up random access memory (RAM) for data storage. Optional RAM modules of up to 40 Mbytes are also available.

The SV^{PLUS} is designed to be used with an IBM compatible computer. The instrument's output is standard ASCII RS-232, permitting data transfer via a 3-conductor cable. The baud rate is automatically selected with the maximum being 19,200. The data output may be configured to display either unprocessed integers, or computed engineering values. The SV^{PLUS} has the options of logging data continuously, by depth increments, by time increments, by sound velocity increments, or logging individual scans.

The aluminium pressure case and sensor protection cages are hard-anodised for corrosion resistance and durability. Nylon bumpers on each end of the instrument provide additional protection.

1.2 About the User

This manual has been written with the following assumptions:

•The user has had some exposure to IBM compatible computers running MS Windows, and is moderately computer literate with a working knowledge of computer operation and terminology.

•The user is familiar with the operation and function of standard communications (terminal) packages.

While it is possible to operate the SV^{PLUS} without these qualifications, some computer experience will greatly assist the user to pass through the learning curve more rapidly.

1.3 Instrument Specifications

Sensors:
   Pressure:

Type:	Keller stainless steel pressure transducer.
Range:	Assorted pressure ranges up to 5000 dBars.
Accuracy:	0.15% of Full Scale.
Resolution:	0.005% of Full Scale.

Response Time: 10 ms

Temperature:

Type:	Pressure protected precision aged thermistor.
Range:	-2°C to 32°C.
Accuracy:	±0.05°C
Resolution:	0.001°C
Response Time:	1 s (Optional: 350ms and 100ms)

Sound Velocity:

Type:	1 Mega Hertz piezoelectric transducer
	INVAR stabilised path length (± 5.5 nm/°C)
Range:	1400 - 1550 m/s
Accuracy:	< 0.06 m/s (R.M.S.)
Resolution:	0.015 m/s

Memory:

128k battery backed-up RAM, expandable to 40 MBytes. The standard RAM can record 6,400 scans of date, time, pressure, temperature, sound velocity, and battery.

Output:

RS-232C, 300 to 19200 baud, ASCII, 8 data bits, no parity, 1 stop bit. The baud rate is automatically determined and selected.

Sample Rate:

When recording internally without sending data, the scan rate is selectable from 10 scans/second to one every 24 hours. If a scan rate is chosen which is faster than the scan rate capability of the instrument the instrument will default to its maximum scan rate.

Time Code:

Real Time Clock. Accuracy: ±1 minute/month at 25°C.

Power:

Standard:	9 Alkaline D-Cells, 6 Amp-hours
Optional:	9 Nickel Cadmium D-Cells, 4.4 Amp-hours
	3 Lithium D-Cells, 14 Amp-hours

4 Alkaline 9 Volt Cells, 2 Amp-hours
External power 8 to 16 V DC

The Amp-hour ratings are approximate and will vary.

Battery Level:	Indicates the battery voltage.
Under Water Connectors:	Impulse[tm] #IL-2S-BC and IL-5S-BC
Shorting Plug:	Impulse[tm] Connector #IL-2P-MPD
Dummy Plug:	Impulse[tm] Connector #IL-5P-MPD
Mating Connector:	Impulse[tm] (Data link cable connector) #IL-5P-MP-Custom (consult factory)
Pressure Housing:	6061-T6 aluminium, hard anodised. All other external parts are type 316 stainless steel. Submersible to 5000 meters of water depth (dependent on installed pressure sensor).

1.4 Warranty

Warranty and Limitation of Liability

AML warrants the instrument for a period of ***one year*** from the date of delivery. AML will repair or replace, at its option and at no charge, components which prove to be defective. The warranty applies only to the original purchaser of the instruments. The warranty does not apply if the instrument has been damaged, by accident or misuse, and is void if repairs or modifications are made by other than authorized personnel.

This warranty is the only warranty given by AML. No warranties implied by law, including but not limited to the implied warranties of merchantability and fitness for a particular purpose shall apply. In no event will AML be liable for any direct, indirect, consequential or incidental damages resulting from any defects or failure of performance of any instrument supplied by AML.

Disclaimer

AML reserves the right to make any changes in design or specifications at any time without incurring any obligation to modify previously delivered instruments. Manuals are produced for information and reference purposes and are subject to change without notice.

Certificate of Calibration

Customer: TerraSond Ltd

Asset Serial Number: 003317

Asset Product Type: SV Plus V1 Instrument

Calibration Type: Pressure

Calibration Range: 500 dBar

Calibration RMS Error: .0074

Calibration ID: 003317 999999 0FZ894 170713 125943

Installed On:

Coefficient A: -4.273065E+2

Coefficient B: 0.000000E+0

Coefficient C: 0.000000E+0

Coefficient D: 0.000000E+0

Coefficient E: 2.405779E-2

Coefficient F: 0.000000E+0

Coefficient G: 0.000000E+0

Coefficient H: 0.000000E+0

Coefficient I: 2.778972E-9

Coefficient J: 0.000000E+0

Coefficient K: 0.000000E+0

Coefficient L: 0.000000E+0

Coefficient M: 0.000000E+0

Coefficient N: 0.000000E+0

Calibration Date (dd/mm/yyyy): 17/7/2013

Certified By:

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

Certificate of Calibration

Customer: TerraSond Ltd

Asset Serial Number: 003317

Asset Product Type: SV Plus V1 Instrument

Calibration Type: Temperature

Calibration Range: 0 to +32 Dec C

Calibration RMS Error: .0046

Calibration ID: 003317 999999 T07002 170713 105739

Installed On:

Coefficient A: 3.508190E+1

Coefficient B: -1.088002E-3

Coefficient C: 8.661361E-9

Coefficient D: -1.511067E-13

Coefficient E: 0.000000E+0

Coefficient F: 0.000000E+0

Coefficient G: 0.000000E+0

Coefficient H: 0.000000E+0

Coefficient I: 0.000000E+0

Coefficient J: 0.000000E+0

Coefficient K: 0.000000E+0

Coefficient L: 0.000000E+0

Coefficient M: 0.000000E+0

Coefficient N: 0.000000E+0

Calibration Date (dd/mm/yyyy): 17/7/2013

Certified By:

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange[TM] sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary.   Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

Certificate of Calibration

Customer: TerraSond Ltd

Asset Serial Number: 003317

Asset Product Type: SV Plus V1 Instrument

Calibration Type: Sound Velocity

Calibration Range: 1400 to 1550 m/s

Calibration RMS Error: .0177

Calibration ID: 003317 999999 200868 170713 004321

Installed On:

Coefficient A:	1.530160E+3	Coefficient H:	0.000000E+0
Coefficient B:	-1.069640E+2	Coefficient I:	0.000000E+0
Coefficient C:	7.407540E+0	Coefficient J:	0.000000E+0
Coefficient D:	-2.131877E-1	Coefficient K:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient L:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient M:	0.000000E+0
Coefficient G:	0.000000E+0	Coefficient N:	0.000000E+0

Calibration Date (dd/mm/yyyy): 17/7/2013

Certified By:

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary.   Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

SeaBat® 7125

Ultra high Resolution Multibeam Echosounder

7125SV2

7125 ROV2

WHY CHOOSE A SEABAT 7125 SYSTEM?

- Maximum productivity during data collection
  Up to165° swath
  Roll Stabilization
  Up to 512 beams in operator selectable modes

- Uncompromised clean data sets
  Quality Filters/flags
  Interactive, Comprehensive GUI
  Industry leading bottom detect methods

- Ease of Installation and Use
  Fully automatic operation
  Single highly integrated topside transceiver
  Integrated Multibeam acquisition and processing software
  Extremely portable wet-end

- Maximum Operational Flexibility
  400 and 200kHz operation for seamless data collection
   from 0.5m to 500m
  Advanced beam-forming with variable and steerable swath
  Simultaneous output of bathymetry, Sidescan, Snippets
  backscatter, and raw water column data
  Optional X-Range for increased range performance, ultra-
   high resolution and resistance to external noise

TELEDYNE RESON
Everywhere**you**look™

SeaBat® 7125

SEABAT 7125 SYSTEM SPECIFICATIONS

	7125 SV2	7125 ROV2	7125 AUV
Power requirement	Typical: 110-220 VAC, 50/60 Hz, 250 W. Max: 110-220 VAC, 50/60 Hz, 700 W.	Processor Typical: 110-220 VAC, 50/60 Hz, 110 W. Processor Max: 110-220 VAC, 50/60 Hz, 400 W. Wet end Typical: 48 VDC (+/- 10%), 115 W. Wet end Max: 48 VDC (+/- 10%) 250 W. Power requirements when Wet-ends are powered from sonar processor: 110-220 VAC, 50/60 Hz, 700 W.	48V DC (± 10%)
Transducer cable length	25m standard	3m standard 10m optional	3m standard 10m optional
LCU to processor cable length	N/A	25m (st), 3 m	N/A
System depth rating	25m	6000m	6000m optional
Frequency	200kHz or 400kHz (dual frequency available)		
Along-track transmit beamwidth	2° at 200kHz & 1° at 400kHz		
Across-track receive beamwidth	1° at 200kHz & 0.5° at 400kHz		
Max ping rate	50Hz (±1Hz)		
Pulse length	30μs – 300μs Continuous Wave; 300μs – 20ms Frequency Modulated (X-Range)		
Number of beams	512EA/ED at 400kHz, 256EA/ED at 200kHz		
Max swath angle	140° in Equi-Distant Mode; 165° in Equi-Angle Mode		
Typical depth [2]	0.5m to 150m at 400kHz, 0.5m to 400m at 200kHz		
Max depth [3]	>175m at 400kHz; 450m at 200kHz		
Depth resolution	6mm		
Data output	Bathmetry, sidescan and snippets 7K data format		
Temperature:	-2° to +35°C		
Flexmode:	Optional		
Full Rate Dual Head	400 KHz for ROV/AUV		

For relevant tolerances for dimensions above and detailed outlined drawings see Product Description
1 All beam widths measured at -3dB, unsteered with a sound velocity of 1480m/s.
2 This is a depth range within which the system is normally operated, from the minimum depth to a depth value corresponding to the max. swath -50%.
3 This is the single value corresponding to the depth at which the swath is reduced to 10% of its max. value. For actual swath performance refer to Product Description.

www.teledyne-reson.com

TELEDYNE RESON
Everywhere**you**look™

POS MV - Marine Vessels

Providing the Marine Industry with Robust, Reliable, and Repeatable position and orientation solutions.

The new POS MV is a tightly-coupled system utilizing Applanix' unique Inertially Aided Real-Time Kinematic (IARTK) technology.

Using Applanix engineering expertise, and configured for maximum operational functionaity, the new system is designed to provide state-of-the-art Position and Orientation data for marine users.

THE V4 ADVANTAGE

Robust
- GPS Positioning – IARTK technology provides almost instantaneous RTK reacquisition following GPS signal loss
- GAMS – Improved GPS Azimuth Measurement System using enhanced algorithms and superior tracking performance for more robust heading aiding
- Orientation – Under the most demanding conditions, POS MV delivers a full six degree-of-freedom position and orientation solution with a high update rate

Reliable
- Incorporating a super-efficient POS computer system (PCS), next generation software, and the latest Trimble GPS technology, POS MV ensures reliable performance

Repeatable
- The system's tightly-coupled capabiity allows for consistent, repeatable results

Straightforward Installation and Operation
- All components mounted and installed using a straightforward, one time only systematic procedure

Faster, More Reliable Networking Potential
- The industry's only complete and reliable raw data logging capability for streamlined data acquisition of all motion variables with microsecond-accurate time stamping

Upgradeability
A convenient upgrade program is available:
- Continuous system enhancement and state-of-the-art functionality allows for constant product upgrades
- L1/L2 upgrade with the Trimble BD950 receiver
- Backwards compatibility:
  - Existing IMU's can still be used
  - PCS replacement only required

POS MV™ marine vessels

- **POS Computer System (PCS)** A rugged, compact computer system contains the core POS processor and IMU interface electronics, plus two GPS receivers and an optional removable PC-card disk drive. The PCS provides system timing, position and velocity aiding, together with GPS raw observables for use with GAMS

- **POS Inertial Measurement Unit** The system's primary sensor allows for the continuous output of position and orientation data

- **Primary GPS Receiver Antenna** A dual frequency antenna that provides GPS observables for the system's tightly-coupled aided Inertial Navigation System

- **Secondary GPS Receiver Antenna** A dual frequency antenna for use with GAMS

REDEFINING THE WAY YOU SURVEY

Next Generation Technology

The new Applanix POS MV V4 system represents the latest in state-of-the-art Integrated Inertial Technology for the marine industry. The system provides a user-friendly, turnkey solution for generating precise, accurate data for marine motion sensing and hydrographic surveying and charting.

TIGHTLY-INTEGRATED INERTIAL NAVIGATION

POS MV V4 enables continuous positioning information to be generated while surveying in areas where GPS reception is compromised by the effects of multipath and satellite signal loss. Raw GPS data from as few as one satellite can be processed directly within the POS MV to reduce position drift and RTK reacquisition time. This characteristic strengthens the system's ability to generate continuous, accurate data irrespective of its proximity to port, harbor, and offshore structures.

THE POS MV V4 ADVANTAGE

- Proprietary approach to Inertially Aided RTK to provide almost instantaneous RTK reacquisition following a GPS signal outage
- Faster and more robust heading aiding from the GPS Azimuth Measurement Subsystem (GAMS)
- Maintains heading accuracy when operating in a high multipath environment and in areas of poor GPS availability
- Superior low-elevation satellite tracking performance regardless of latitude
- Faster initial system calibration
- Automatic identification and error estimation for lever arm distances and angles

UTILIZING THE LATEST TRIMBLE TECHNOLOGY

POS MV V4 uses the latest GPS technology from Trimble – the BD950 Compact Card receiver together with Zephyr™ geodetic antennas to provide the following:

- Fast response time
- Very low noise L1 and L2 carrier phase measurements
- Enhanced tracking capability using the Maxwell 4 Custom Survey GPS chip
- Increased component reliability
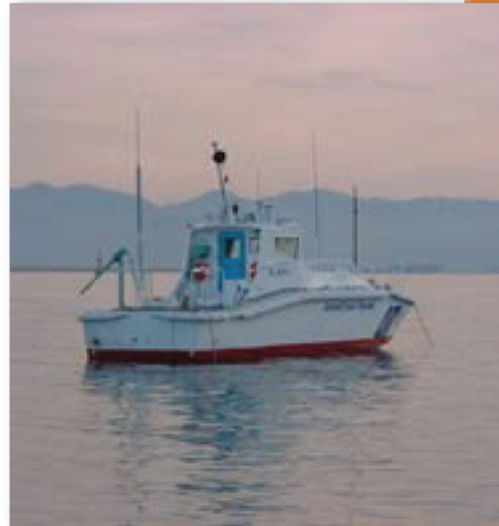
Next Generation TechnologyN

GENERATING THE MOST ACCURATE POSITION AND ORIENTATION SOLUTION

Even when operating under the most demanding conditions, POS MV V4 will maintain positioning accuracy regardless of vessel dynamics. The system delivers a full six degree-of-freedom position and orientation solution, with a high update rate, to provide the following:

- Position (latitude, longitude and elevation)
- Velocity (north, east and vertical)
- Attitude (roll, pitch and true heading)
- Heave (real-time, delayed)
- Acceleration Vectors
- Angular Rate Vectors

POS MV - A FIELD PROVEN TECHNOLOGY

Currently in service with many of the world's largest marine contractors and navies, POS MV is a proven performer, engineered for successful operations when robust, reliable and repeatable solutions are required.

Above - The GRAM-S GPS Receiver Interface Chassis

Force 5 Gram-S GPS Receiver Interface

The Applanix GPS precise positioning interface is designed for straightforward plug-and-play utilization of the Force 5 GRAM-S receiver - the receiver solution for embedded military applications.

Designed for military use to address Global Air Traffic Management (GATM) and Navigation Warfare (NAVWAR) requirements, the Force 5 GRAM-S module is a versatile, dual frequency receiver that provides both Standard Positioning Service (SPS) and Precise Positioning Service (PPS) capability. Easily integrated as a standalone GPS receiver, or coupled with inertial or Doppler navigation systems, the Force 5 provides maximum retrofit flex bility.

The unit incorporates the latest in advanced GPS technology with a Selective Availability Anti-Spoofing Module (SAASM), which enables a more robust solution when undertaking critical and complex military operations.

Granted the NAVSTAR GPS Joint Program Office Security Approval, Force 5 GRAM-S is used under military conditions with single/multibeam sonar systems. It includes the following key features:

- Dual frequency tracking and navigation
- SPS/PPS firewall and switch
- Fault detection and exclusion
- Kalman filter for integration with Inertial or Doppler systems
- Direct Y Code acquisition for operation in high-jamming environment

TrueHeave Advantages
TrueHeave Technology - Software Precision and Accuracy with no compromise

In re-affirming its position as the provider of leading edge motion sensor systems, Applanix has redefined the accuracy and reliability of heave data by introducing TrueHeave technology. Using new heave processing algorithms, TrueHeave now enables heave data to meet and exceed the highest marine industry standards.

POS MV WITH TRUEHEAVE

TrueHeave has overcome the conventional limitations of current motion system technology by filtering real-time data to remove phase errors and provide extremely accurate amplitude information. Based on an advanced two-sided filtering technique, TrueHeave technology uses both past and present vertical motion to compute a significantly improved heave estimate.

POS MV systems equipped with TrueHeave

have sufficient computational speed to generate the secondary estimate of heave shortly after the initial sonar acquisition event.

Delayed time heave output not only removes many of the compromises that must be made in real-time, but also provides near real-time QC of heave performance. This can be seen in the time series plots of both real-time and TrueHeave estimates, which allow the operator to react accordingly if a divergence between the two is observed.

PERFORMANCE AND RESULTS

The following panels illustrate sun illuminated data sets of a number of passes along the same line, using real-time heave and TrueHeave technology. The lower image shows red and yellow profiles of a single line (within the yellow boxes depicted
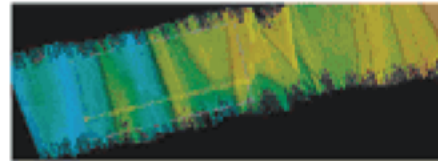
Real time heave - 3x vertical exaggeration
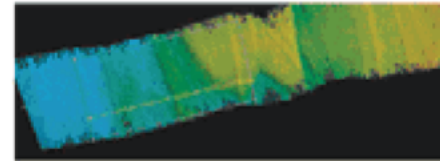
TrueHeave - 3x vertical exaggeration

TrueHeave Advantages Ê

in the upper panel) which was running with the sea, inducing a long relative swell. The red profile was produced using TrueHeave, the yellow profile generated with real-time heave. The depth difference between the two lines is approximately 20cm, at the point indicated by the dashed orange line, which is a substantial improvement in heave accuracy. Heave artifacts are dramatically reduce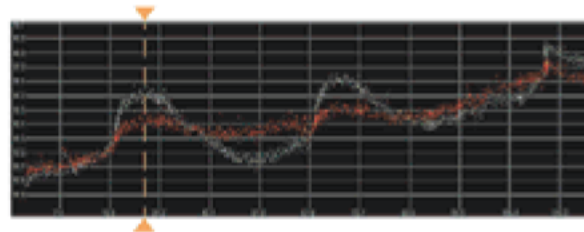d under the most challenging conditions, including long-period motion, variable swells, and turn-induced heave period changes. Regardless of the sea conditions and vessel dynamics, TrueHeave will provide optimal results with outstanding performance.

COST EFFECTIVE SOLUTION

By utilizing TrueHeave software, the reduction in filter settling time can eliminate the requirement for survey line run-ins. This can increase your operational capability and bring down operational costs.
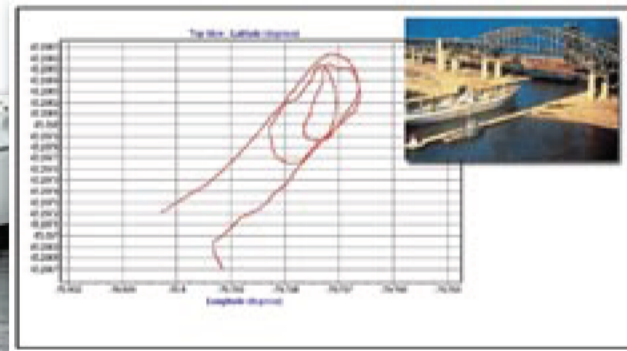
Above – Vessel trajectory under the Burlington Skyway bridge, using TrueHeave

System Specifications

ACCURACY SPECIFICATIONS

POS MV 320

	Main Specifications *(With Differential Corrections)*	During GPS Outage
Roll, Pitch Accuracy	0.02° (1 sigma with GPS or DGPS) 0.01° (1 sigma with RTK)	0.02° (1 sigma)
Heave Accuracy	5 cm or 5% (whichever is greater) for periods of 20 seconds or less	5 cm or 5% (whichever is greater) for wave periods of 18s or less
Heading Accuracy	0.02° (1 sigma) with 2 m antenna baseline, 0.01 (1 sigma) with 4 m baseline	Drift less than 1° per hour (negligble for outages < 60s)
Position Accuracy	0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver 0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver	2.5 m (1 sigma) for 30 s outages <6 m (1 sigma) for 60 s outages
Velocity Accuracy	0.03 m/s horizontal	

PHYSICAL SPECIFICATIONS

Size		
IMU	204 mm x 204 mm x 168 mm	7.95 in x 7.95 in x 6.55 in
PCS	432 mm x 89 mm x 356 mm	17.00 in x 3.50 in x 14.05 in
	2.0U 19 in rack mount	
GPS Antenna (x2)	187 mm x 53 mm	7.4 in x 2.1 in
Weight		
IMU	3.5 kg	7.7 lb (international)
PCS	5 kg	11.0 lb (international)
GPS Antenna	<0.5 kg	<1.1 lb (international)
Power		
IMU	Power provided by PCS	
PCS	110/230 Vac, 50/60 Hz, auto-switching 80 Watt	
GPS Antenna	Power provided by PCS	

ENVIRONMENTAL SPECIFICATIONS

Temperature Range (Operating)		
IMU	-40°C to +60°C	-40°F to +140°F
PCS	0°C to +55°C	+32°F to +131°F
GPS Antenna	-40°C to +70°C	-40°F to +158°F
Temperature Range (Storage)		
IMU	-40°C to +60°C	-40°F to +140°F
PCS	-25°C to +85°C	-13°F to +185°F
GPS Antenna	-50°C to +70°C	-58°F to +158°F
Humidity		
IMU	10 - 80% RH, Ingress Protection of 65	
PCS	10 - 80% RH, non- condensing	
GPS Antenna	0 - 100% RH	
Shock & Vibration (IMU)		
Operating	90 g, 6 ms terminal saw tooth	
Non-Operating	220 g, 5 ms half-sine	

Ethernet (100 base-T)	
Parameters	Time tag, status, position, attitude, heave, velocity, track and speed, dynamics, performance metrics, raw IMU data, raw GPS data
Display Port	Low rate (1 Hz) UDP protocol output
Control Port	TCP/IP input for system commands
Data Port 1	Real-time (up to 200 Hz) UDP protocol output
Data Port 2	Buffered TCP/IP protocol output for data logging to external device
Serial RS323 I/O	
5 COM Ports	User assignable to: NMEA output, Binary output, Auxiliary GPS input (2), Base GPS correction input (2)
NMEA ASCII Output	
Parameters	NMEA Standard ASCII messages: Position ($INGGA, $INGGK), Heading ($INHDT), Track and Speed ($INVTG), Statistics ($INGST), Attitude ($PASHR, $PRDID), Time and Date ($INZDA, $UTC).
Rate	Up to 50 Hz (user selectable)
High Rate Attitude Output	
Parameters	User selectable binary messages: attitude, heading, speed
Rate	Up to 100 Hz (user selectable)

System Specifications

ACCURACY SPECIFICATIONS

POS MV WaveMaster

	Main Specifications *(With Differential Corrections)*	During GPS Outage
Roll, Pitch Accuracy	0.0.03° (1 sigma with GPS or DGPS) 0.02° (1 sigma with RTK)	0.04° (1 sigma)
Heave Accuracy	5 cm or 5% (whichever is greater) for periods of 20 seconds or less	5 cm or 5% (whichever is greater) for wave periods of 18s or less
Heading Accuracy	0.06° (1 sigma) with 1 m antenna baseline, 0.03 (1 sigma) with 2 m baseline, 0.015 (1 sigma) with 4 m baseline	Drift less than 2° per hour
Position Accuracy	0.5 - 2 m (1 sigma) depending on quality of differential corrections 0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver	3 m (1 sigma) for 30 s outages <10 m (1 sigma) for 60 s outages
Velocity Accuracy	0.05 m/s horizontal	

PHYSICAL SPECIFICATIONS

Size

IMU	160 mm x 160 mm x 102 mm	6.3 in x 6.3 in x 4.0 in
PCS	281 mm x 165 mm x 90 mm	11.0 in x 6.5 in x 3.5 in
GPS Antenna (x2)	187 mm x 53 mm	7.4 in x 2.1 in

Weight

IMU	3.6 kg	8 b (international)
PCS	3.0 kg	6.6 lb (international)
GPS Antenna	<0.5 kg	<1.1 lb (international)

Power

PCS	24vdc, 50 W (peak)
IMU	Power provided by PCS
GPS Antenna	Power provided by PCS

ENVIRONMENTAL SPECIFICATIONS

Temperature Range (Operating)

IMU	-40°C to +60°C	-40°F to +140°F
PCS	-20°C to +60°C	-4°F to +140°F
GPS Antenna	-40°C to +70°C	-40°F to +158°F

Temperature Range (Storage)

IMU	-40°C to +60°C	-40°F to +140°F
PCS	-20°C to +60°C	-4°F to +140°F
GPS Antenna	-40°C to +70°C	-40°F to +158°F

Humidity

IMU	10 - 80% RH, Ingress Protection of 65
PCS	5 - 90% RH, non- condensing
GPS Antenna	0 - 100% RH

Ethernet (100 base-T)

Parameters	Time tag, status, position, attitude, heave, velocity, track and speed, dynamics, performance metrics, raw IMU data, raw GPS data
Display Port	Low rate (1 Hz) UDP protocol output
Control Port	TCP/IP input for system commands
Data Port 1	Real-time (up to 200 Hz) UDP protocol output
Data Port 2	Buffered TCP/IP protocol output for data logging to external device

Serial RS323 I/O

5 COM Ports	User assignable to: NMEA output, Binary output, Auxiliary GPS input (2), Base GPS correction input (2)

NMEA ASCII Output

Parameters	NMEA Standard ASCII messages: Position ($INGGA, $INGGK), Heading ($INHDT), Track and Speed ($INVTG), Statistics ($INGST), Attitude ($PASHR, $PRDID), Time and Date ($INZDA, $UTC).
Rate	Up to 50 Hz (user selectable)

High Rate Attitude Output

Parameters	User selectable binary messages: attitude, heading, speed
Rate	Up to 100 Hz (user selectable)

System Specifications

ACCURACY SPECIFICATIONS

POS MV WaveMaster RM

	Main Specifications *(With Differential Corrections)*	During GPS Outage
Roll, Pitch Accuracy	0.0.03° (1 sigma with GPS or DGPS) 0.02° (1 sigma with RTK)	0.04° (1 sigma)
Heave Accuracy	5 cm or 5% (whichever is greater) for periods of 20 seconds or less	5 cm or 5% (whichever is greater) for wave periods of 18s or less
Heading Accuracy	0.06° (1 sigma) with 1 m antenna baseline, 0.03 (1 sigma) with 2 m baseline, 0.015 (1 sigma) with 4 m baseline	Drift less than 2° per hour
Position Accuracy	0.5 - 2 m (1 sigma) depending on quality of differential corrections 0.02 - 0.10 m (RTK) with input from auxiliary RTK or optional internal RTK receiver	3 m (1 sigma) for 30 s outages <10 m (1 sigma) for 60 s outages
Velocity Accuracy	0.05 m/s horizontal	

PHYSICAL SPECIFICATIONS

Size		
IMU	160 mm x 160 mm x 102 mm	6.3 in x 6.3 in x 4.0 in
PCS	432 mm x 89 mm x 356 mm	17.00 in x 3.50 in x 14.05 in
	2.0U 19 in rack mount	
GPS Antenna (x2)	187 mm x 53 mm	7.4 in x 2.1 in
Weight		
IMU	3.6 kg	8 lb (international)
PCS	5.0 kg	11.0 lb (international)
GPS Antenna	<0.5 kg	<1.1 lb (international)
Power		
PCS	110/230 Vac, 50/60 Hz, auto-switching 80 Watt	
IMU	Power provided by PCS	
GPS Antenna	Power provided by PCS	

ENVIRONMENTAL SPECIFICATIONS

Temperature Range (Operating)		
IMU	-40°C to +60°C	-40°F to +140°F
PCS	0°C to +55°C	+32°F to +131°F
GPS Antenna	-40°C to +70°C	-40°F to +158°F
Temperature Range (Storage)		
IMU	-40°C to +60°C	-40°F to +140°F
PCS	-25°C to +85°C	-13°F to +185°F
GPS Antenna	-40°C to +70°C	-40°F to +158°F
Humidity		
IMU	10 - 80% RH, Ingress Protection of 65	
PCS	10 - 80% RH, non- condensing	
GPS Antenna	0 - 100% RH	

Ethernet (100 base-T)	
Parameters	Time tag, status, position, attitude, heave, velocity, track and speed, dynamics, performance metrics, raw IMU data, raw GPS data
Display Port	Low rate (1 Hz) UDP protocol output
Control Port	TCP/IP input for system commands
Data Port 1	Real-time (up to 200 Hz) UDP protocol output
Data Port 2	Buffered TCP/IP protocol output for data logging to external device
Serial RS323 I/O	
5 COM Ports	User assignable to: NMEA output, Binary output, Auxiliary GPS input (2), Base GPS correction input (2)
NMEA ASCII Output	
Parameters	NMEA Standard ASCII messages: Position ($INGGA, $INGGK), Heading ($INHDT), Track and Speed ($INVTG), Statistics ($INGST), Attitude ($PASHR, $PRDID), Time and Date ($INZDA, $UTC).
Rate	Up to 50 Hz (user selectable)
High Rate Attitude Output	
Parameters	User selectable binary messages: attitude, heading, speed
Rate	Up to 100 Hz (user selectable)

Dual-Frequency GNSS Receiver

- Vanguard Technology™
- Universal Tracking Technology
- Rugged, Magnesium Alloy Construction
- Integrated RTK and Static Receiver
- Fence Antenna™ Advanced Performance

HiPer V Dual-Frequency GNSS Receiver

Compact, cable-free solution with Vanguard Technology for all GNSS positioning applications.

Topcon enhances the HiPer family of products by adding Vanguard Technology to the HiPer V. In the early 2000's Topcon revolutionized GNSS receivers by integrating the design to be compact and light weight. Topcon continues the revolution with Vanguard Technology™.

Topcon raises the standard once again by adding Vanguard Technology with 226 channels, Universal Tracking Technology, and the Fence Antenna into the versatile and configurable HiPer V. Universal Tracking Technology is an advanced firmware process that allows each of the 226 channels to be assigned to any satellite signal.

GPS, GLONASS, and Galileo Signal Tracking

The HiPer V is capable of tracking GPS, GLONASS, and Galileo signals. The recent addition of Galileo E1 band of signals will provide better performance in difficult environments such as urban canyons and forested areas.

Internal Radio Configurations

The HiPer V can be configured with the radio and cellular modem that best fits your needs. You can choose from Digital UHF or Spread Spectrum radio. Further, you can choose from HSPA, CDMA, or no cellular module. If you start your HiPer V investment with static only receivers, they can later be upgraded to include radio and cellular modules at one of many Topcon service facilities around the globe.
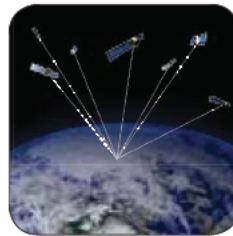

Integrated Radio and Modem Choice

- Spread Spectrum Radio
- Digital UHF II Radio
- HSPA Cellular Modem
- CDMA Modem

Rugged Design

- Magnesium metal housing
- Drop-proof
- Durable, rugged
- Waterproof

Integrated GPS, GLONASS, Galileo

- USA based GPS satellites
- Russian based GLONASS satellites
- European based Galileo satellites

Housing Features

- External power port
- External serial port
- Tape measure hook
- Shock protected ring

Rugged and Waterproof

The HiPer V is designed rugged enough to perform in a real jobsite. It is also waterproof IP67, which means it can be submersed into water. The ports, speaker and battery door are all completely sealed from dust and water.

Voice Alerts

Voice status messages keep you informed without having to look at the screen of the field controller, or the status lights above your head. Stay safe in traffic situations by looking at oncoming traffic rather than looking for the word "Fixed".

TOPCON

VANGUARD TECHNOLOGY

Session timer

Fence Antenna™

Bluetooth® connectivity

TOPCON

HIPER

Internal *Bluetooth®* module

Power button

Remaining battery

Number of satellites being tracked

Remaining memory

Serial connectivity

Radio connectivity

Fence Antenna™ Technology

This superior GNSS antenna element is light-weight, rugged, and sensitive enough to track signals in environments where other receivers fail. Obtain lock sooner, and track longer with Fence Antenna™ technology.
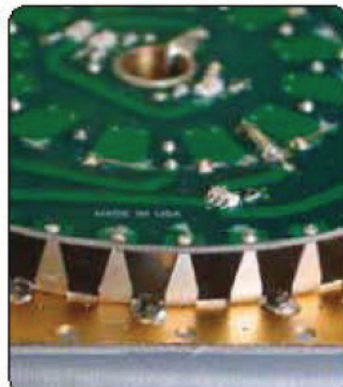
System Components

- 2x HiPer V Receivers
- 4x Batteries, 2x Chargers and Cables
- Radio Antenna
- Carrying Case
- 10cm Spacer and 3m Tape Measure
- Tribrach and Adapter w/Optical Plummet

SPECIFICATIONS

Tracking Capabilities

Number of Channels		226 Channels with Universal Tracking Technology
Tracked Signals	GPS	L1 CA, L1/L2 P-code, L2C
	GLONASS	L1/L2 CA, L1/L2 P-code
	Galileo	E1*
	SBAS	WAAS, EGNOS, MSAS, QZSS

Positioning Accuracy

Static	L1+L2	H: 3mm + 0.5ppm
		V: 5mm + 0.5ppm
	L1 only	H: 3mm + 0.8ppm
		V: 4mm + 1ppm
RTK, Kinematic	L1+L2	H: 10mm + 1ppm
		V: 15mm + 1ppm
DGPS		<0.5m

Wireless Communication

Bluetooth®	V2.1 + EDR, Class 2, 115,200bps
Radio	UHF, Spread Spectrum, Cellular (options)

Environmental

Dust/Water Protection	IP67
Shock	6.56 ft. (2m) pole drop
Operating Temperature	
External Power	-40°F to +149°F (-40°C to +65°C)
Battery	-4°F to +149°F (-20°C to +65°C)
Cellular	-4° to +131°F (-20° to +55°C)

Physical

Enclosure	Magnesium alloy housing
Size	7.24" D x 3.74" H (184mm D x 95mm H)
Weight	HiPer V receiver 2.20 lb. to 2.82 lb. (1.0kg to 1.28kg)
Battery (BDC70)	7.23 oz. (195g)

Power Supply

Standard Battery	Detachable, Li-ion rechargeable battery, 7.2V, 4.3Ah
Operating Time at 68°F (20°C)	>7.5 hours in static mode w/*Bluetooth*® connection
External Power Input Voltage	6.7 to 18V DC

* Support for Galileo will be available via option file upgrade when the constellation is fully operational and ready for commercial use.

For more specifications information:
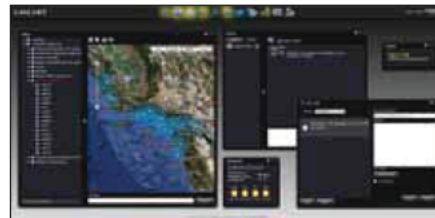**www.topcon-positioning.eu**

SOFTWARE

MAGNET™

A family of software solutions that streamlines the workflow for surveyors, contractors, engineers and mapping professionals.

MAGNET Field

MAGNET Field provides a bright, graphical user interface with large touch icons and bright readable text. Select your color scheme Black, Gold, Blue, Silver, for your best visibility.

MAGNET Enterprise

A managers dream of tracking all field and office data in one simple to access web interface. Store and exchange your field data in the Enterprise cloud.

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MAGNET Office

Full CAD functionality with MAGNET Office Site and Topo. Or field data processing with MAGNET Office Tools inside AutoCAD® products, like Civil3D®. The MAGNET Office solution has what you need.

TOPCON
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Your local Authorized Topcon dealer is:

Receiver Name	**SPS855 GNSS Modular Receiver**
Configuration Option	
Base and Rover interchangeability	Yes, upgradeable to Rover, Base or Rover / Base
Rover position update rate	1 Hz, 2 Hz, 5 Hz, 10 Hz, 20 Hz
Rover maximum range from base radio	Unrestricted, typical range 2–5 km (1.2–3 miles) without radio repeater
Rover operation within a VRS™ network	Yes
Heading and Moving Base operation	Yes - option[7]
Factory options	See Receiver Upgrades below

General	
Keyboard and display	Vacuum Fluorescent display 16 characters by 2 rows. Invertable
	On/Off key for one-button startup
	Escape and Enter keys for menu navigation
	4 arrow keys (up, down, left, right) for option scrolls and data entry
Dimensions (L × W × D)	24 cm × 12 cm × 5 cm (9.4 in x 4.7 in x 1.9 in) including connectors
Weight	1.65 kg (3.64 lb) receiver with internal battery and radio
	1.55 kg (3.42 lb) receiver with internal battery and no radio

Antenna Options	
GA510	L1/L2/L2C GPS, SBAS, and OmniSTAR
GA530	L1/L2/L2C GPS, SBAS, and OmniSTAR
GA810	L1/L2/L2C GPS, Glonass, Galileo, BeiDou, OmniSTAR, SBAS (optimized for OmniSTAR)
L1/Beacon, DSM 232	Not Supported
Zephyr™ Model 2	L1/L2/L2C/L5 GPS, Glonass, Galileo, BeiDou, OmniSTAR, SBAS
Zephyr Geodetic™ Model 2	L1/L2/L2C/L5 GPS, Glonass, Galileo, BeiDou, OmniSTAR, SBAS
Zephyr Model 2 Rugged	L1/L2/L2C/L5 GPS, Glonass, Galileo, BeiDou, OmniSTAR, SBAS
Zephyr, Zephyr Geodetic, Z-Plus, Micro-Centered™	Refer to Antenna specification

Temperature	
Operating[1]	-40 ℃ to +65 ℃ (-40 ℉ to +149 ℉)
Storage	-40 ℃ to +80 ℃ (-40 ℉ to +176 ℉)
Humidity	MIL-STD 810F, Method 507.4
Waterproof	IP67 for submersion to depth of 1 m (3.3 ft), dustproof

Shock and Vibration	
Pole drop	Designed to survive a 1 m (3.3 ft) pole drop onto a hard surface
Shock – Non-operating	To 75 g, 6 ms
Shock – Operating	To 40 g, 10 ms, saw-tooth
Vibration	Tested to Trimble ATV profile (4.5 g RMS): 10 Hz to 300 Hz: 0.04 g/Hz^2
	300 Hz to 1,000 Hz; –6 dB/octave

Trimble SPS855
GNSS Modular Receiver

Measurements

Advanced Trimble Maxwell™ 6 Custom GPS Chips

High-precision multiple correlator for GNSS pseudorange measurements

Unfiltered, unsmoothed pseudo-range measurements data for low noise, low multipath error, low-time domain correlation, and high-dynamic response

Very low noise carrier phase measurements with <1 mm precision in a 1 Hz bandwidth

Trimble EVEREST™ multipath signal rejection

L-Band: OmniSTAR VBS, HP, XP, G2 by subscription

GPS L1 C/A, L2C, L2E (Trimble method for tracking unencrypted L2P) upgradable to L5. 440 channels

Upgradeable to GLONASS L1/L2C/A, L1/L2P Full Cycle Carrier

Upgradeable to Galileo: L1 CBOC, E5A, E5B & E5AltBOC[8]

Upgradeable to BeiDou: B1, B2

4-channel SBAS L1 C/A, L5 (WAAS/EGNOS/MSAS)

QZSS: L1 C/A, L1C, L1 SAIF, L2C, L5

SBAS (WAAS/EGNOS/MSAS) Positioning[3]
Accuracy

Better than 5 m 3DRMS (16 ft)

Code Differential GPS Positioning[2]
Horizontal accuracy

0.25 m + 1 ppm RMS (0.8 ft + 1 ppm RMS)

Vertical accuracy

0.50 m + 1 ppm RMS (1.6 ft + 1 ppm RMS)

OmniSTAR Positioning
VBS service accuracy

Horizontal <1 m (3.3 ft)

XP service accuracy

Horizontal 0.2 m (0.66 ft), Vertical 0.3 m (1.0 ft)

HP service accuracy

Horizontal 0.1 m (0.33 ft), Vertical 0.15 m (0.5 ft)

xFill Positioning
xFill accuracy

RTK[11] + 10mm(0.03 ft)/min Horiz. + 20mm(0.06 ft)/min Vert. RMS

Location RTK Positioning
Horizontal accuracy

Location RTK (10/10) or (10/2) 10 cm + 1 ppm RMS (0.32 ft + 1 ppm)

Vertical accuracy

Location RTK (10/10) 10 cm + 1 ppm RMS (0.32 ft + 1 ppm)

Location RTK (10/2) 2 cm + 1 ppm RMS (0.065 ft + 1 ppm)

Real-Time Kinematic (RTK up to 30 km)
Positioning[2]
Horizontal accuracy

8 mm + 1 ppm RMS (0.026 ft + 1 ppm RMS)

Vertical accuracy

15 mm + 1 ppm RMS (0.05 ft +1 ppm RMS)

Trimble VRS[9]
Horizontal accuracy

8 mm + 0.5 ppm RMS (0.026 ft +0.5 ppm)

Vertical accuracy

15 mm + 0.5 ppm RMS (0.05 ft +0.5 ppm)

Precise Heading
Heading accuracy

Combined with SPS555H[7]

2 m antenna separation

0.09° RMS

10 m antenna separation

0.05° RMS

Initialization Time
Regular RTK operation with base station

Single/Multi-base
typically less than 8 seconds

Initialization reliability[4]

>99.9%

Power
Internal

Integrated internal battery 7.2 V, 7800 mA-hr, Lithium-ion

Internal battery operates as a UPS during an ext power source failure

Internal battery will charge from external power source as long as source can support the power drain

Integrated charging circuitry

Trimble.

Trimble SPS855
GNSS Modular Receiver

Power

External	Power input on 7-pin 0-shell Lemo connector is optimized for lead acid batteries with a cut-off threshold of 11.5 V
	Power input on the 26-pin D-sub connector is optimized for Trimble lithium-ion battery input with a cut-off threshold of 10.5 V
	Power source supply (Internal/External) is hot-swap capable in the event of power source removal or cut off
	DC external power input with over-voltage protection
	Receiver automatically turns on when connected to external power
Power over Ethernet (PoE)	N/A
Power consumption	6.0 W in rover mode with internal receive radio
	8.0 W in base mode with internal transmit radio

Operation Time on Internal Battery

Rover	13 hours; varies with temperature
Base station	
450 MHz systems	Approximately 11 hours; varies with temperature[5]
900 MHz systems	Approximately 9 hours; varies with temperature

Regulatory Approvals

FCC: Part 15 Subpart B (Class B Device) and Subpart C, Part 90

Canadian ICES-003. Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Canadian RSS-310, RSS-210, and RSS-119.
Cet appareil est conforme à la norme CNR-310, CNR-210, et CNR-119 du Canada.

R&TTE Directive: EN 301 489-1/-5/-17, EN 300 440, EN 300 328, EN 300 113, EN 60950, EN 50371

ACMA: AS/NZS 4295 approval

CE mark compliance

C-tick mark compliance

UN ST/SG/AC.10.11/Rev. 3, Amend. 1 (Lithium-ion Battery)

UN ST/SG/AC. 10/27/Add. 2 (Lithium-ion Battery)

RoHS compliant

WEEE compliant

Communications

Lemo (Serial)	7-pin 0S Lemo, Serial 1, 3-wire RS-232
Modem 1 (Serial)	26-pin D-sub, Serial 2, Full 9-wire RS232, using adaptor cable
Modem 2 (Serial)	26-pin D-sub, Serial 3, 3 wire RS-232, using adaptor cable
1PPS (1 Pulse-per-second)	Available on Marine versions
Ethernet	Through a multi-port adaptor
WiFi	N/A
Bluetooth wireless technology	Fully-integrated, fully-sealed 2.4 GHz Bluetooth module[6]
Integrated radios (optional)	Fully-integrated, fully-sealed internal 410-470 MHz Tx/Rx; Internal 900 MHz Tx/Rx
Channel spacing (450 MHz)	12.5 kHz or 25 kHz spacing available
Sensitivity (450 MHz)	-114 dBm (12 dB SINAD)
450 MHz output power	0.5 W, 2.0 W (2.0 W available only in certain countries)
900 MHz output power	1.0 W
Frequency approvals (902-928 MHz)	USA/Canada
External GSM/GPRS, cell phone support	Supported for direct-dial and Internet-based correction streams – directly using the external SNM940 or using the SCS900 software
	Cell phone or GSM/GPRS modem inside controller or external SNM940

Trimble

Internal MSK Beacon receiver	N/A
Receiver position update rate	1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz positioning
Correction data input	CMR™, CMR+™, CMRx™, RTCM 2.x, RTCM 3 (require Rover upgrade)
Correction data output	CMR, CMR+, CMRx, RTCM 2.x, RTCM 3 (require Base upgrade)
Data outputs	NMEA, GSOF. 1PPS Time Tags (Marine version)

Receiver Upgrades

Location RTK (10/2), (10/10), or (30/30)
Precision RTK Base, Rover or Base/Rover, xFill
L5, GLONASS, GALILEO, BeiDou GNSS[10]
28 MB Internal Data Logging option. Moving Base and Heading
2 Watt upgrade for 450 MHz radio

Notes

1 Receiver will operate normally to those temperature limits. Internal batteries will operate from −20 ℃ to +48 ℃

2 Accuracy and reliability may be subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended survey practices.

3 Depends on SBAS system performance.

4 May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

5 If your receiver has the 2.0 W upgrade, you will experience reduced battery performance compared to the 0.5 W solution.

6 Bluetooth type approvals are country specific. For more information, contact your local Trimble office or representative.

7 When receiver is combined with an SPS555H or other suitable SPS receivers. SPS855 must have Moving base option installed

8 Galileo Commercial Authorization
Developed under a Licence of the European Union and the European Space Agency.

9 Networked RTK PPM values are referenced to the closest physical base station

10 This Trimble SPS Receiver is capable of supporting existing and planned GNSS satellite signals, including GPS, GLONASS, GALILEO, BeiDou and QZSS, and existing and planned augmentations to these GNSS systems.
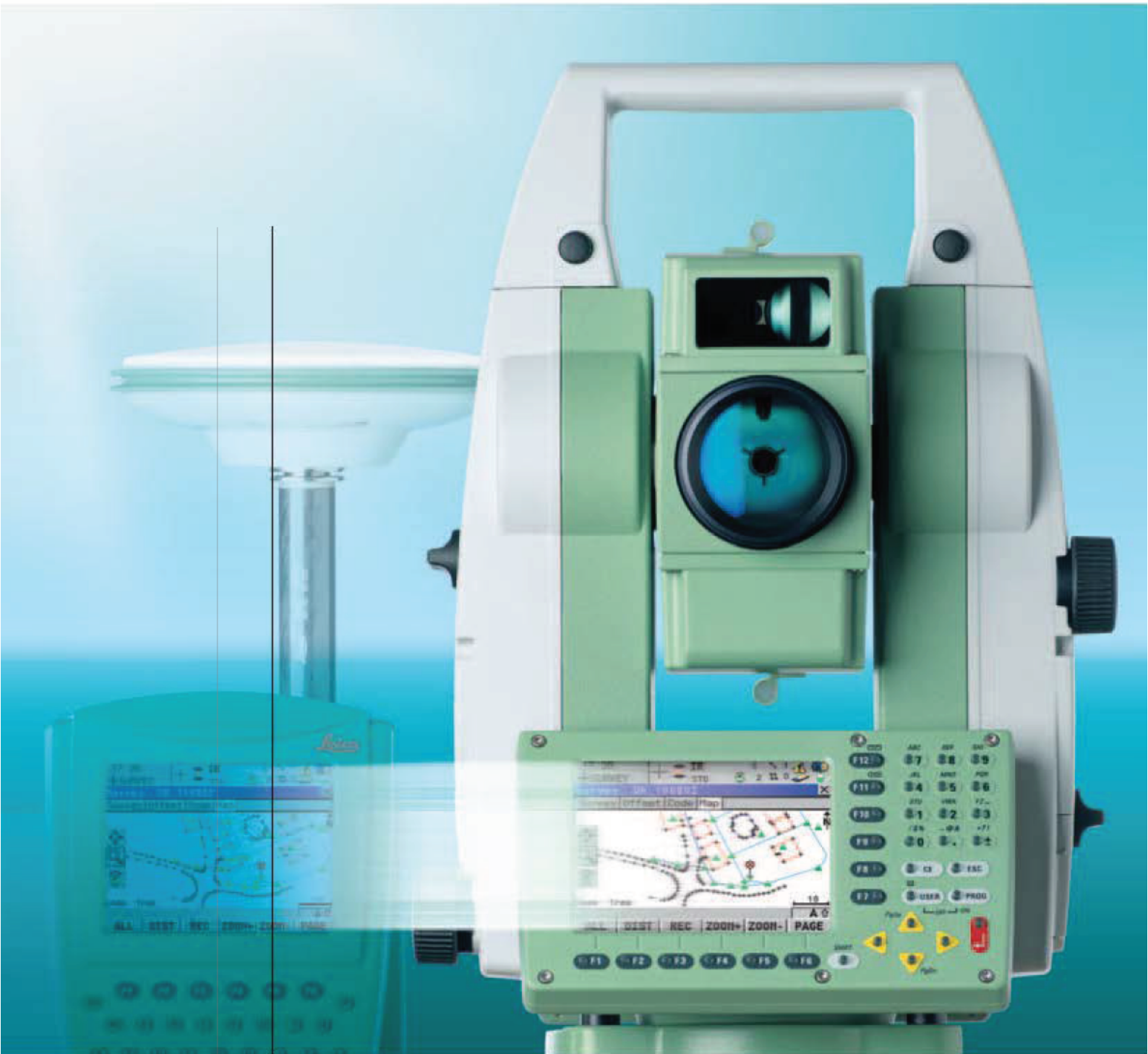
11 RTK refers to the last reported precision before the correction source was lost and xFill started

Specifications subject to change without notice.

⊕ Trimble.

Leica TPS1200+ Series
High performance
Total Station

- when it has to be **right**

Leica
Geosystems

Leica TPS1200+
Technical specifications and system features

Models and options

	TC	TCR	TCRM	TCA	TCP	TCRA	TCRP
Angle measurement	•	•	•	•	•	•	•
Distance measurement (IR-Mode)	•	•	•	•	•	•	•
PinPoint reflectorless dist. measurem. (RL-Mode)		•	•			•	•
Motorized			•	•	•	•	•
Automatic Target Recognition (ATR)				•	•	•	•
PowerSearch (PS)					•		•
Guide Light (EGL)	○	○	○	•	•	•	•
Remote Control Unit / RadioHandle	○	○	○	○	○	○	○
GUS74 Laser Guide				○		○	
SmartStation (ATX1230+ GNSS)	○	○	○	○	○	○	○

• = Standard   ○ = Optional

Angle measurement

		Type 1201+	Type 1202+	Type 1203+	Type 1205+
Accuracy (std.dev., ISO 17123-3)	Hz, V	1'' (0.3 mgon)	2'' (0.6 mgon)	3'' (1 mgon)	5'' (1.5 mgon)
	Display resolution:	0.1'' (0.1 mgon)	0.1'' (0.1 mgon)	0.1'' (0.1 mgon)	0.1'' (0.1 mgon)
Method	absolute, continuous, diametrical				
Compensator	Working range:	4' (0.07 gon)	4' (0.07 gon)	4' (0.07 gon)	4' (0.07 gon)
	Setting accuracy:	0.5'' (0.2 mgon)	0.5'' (0.2 mgon)	1.0'' (0.3 mgon)	1.5'' (0.5 mgon)
	Method:	centralized dual axis compensator			

Distance measurement (IR-Mode)

Range	Round prism (GPR1):	3000 m
(average atmospheric conditions)	360° reflector (GRZ4):	1500 m
	Mini prism (GMP101):	1200 m
	Reflective tape (60 mm x 60mm)	250 m
	Shortest measurable distance:	1.5 m
Accuracy / Measurement time	Standard mode:	1 mm + 1.5 ppm / typ. 2.4 s
(standard deviation, ISO 17123-4)	Fast mode:	3 mm + 1.5 ppm / typ. 0.8 s
	Tracking mode:	3 mm + 1.5 ppm / typ. < 0.15 s
	Display resolution:	0.1 mm
Method	Special phase shift analyzer (coaxial, visible red laser)	

PinPoint R400/R1000 reflectorless distance measurement (RL-Mode)

Range	PinPoint R400:	400 m / 200 m (Kodak Gray Card: 90 % reflective / 18 % reflective)
(average atmospheric conditions)	PinPoint R1000:	1000 m / 500 m (Kodak Gray Card: 90 % reflective / 18 % reflective)
	Shortest measurable distance:	1.5 m
	Long Range to round prism (GPR1):	1000 m – 7500 m
Accuracy / Measurement time	Reflectorless < 500 m:	2 mm + 2 ppm / typ. 3 – 6 s, max. 12 s
(standard deviation, ISO 17123-4)	Reflectorless > 500 m:	4 mm + 2 ppm / typ. 3 – 6 s, max. 12 s
(object in shade, sky overcast)	Long Range:	5 mm + 2 ppm / typ. 2.5 s, max. 12 s
Laser dot size	At 30 m:	approx. 7 mm x 10 mm
	At 50 m:	approx. 8 mm x 20 mm
Method	PinPoint R400 / R1000:	System analyzer (coaxial, visible red laser)

Motorized

Maximum speed	Rotating speed:	45° / s

Automatic Target Recognition (ATR)

Range ATR mode / LOCK mode	Round prism (GPR1):	1000 m / 800 m
(average atmospheric conditions)	360° reflector (GRZ4, GRZ122):	600 m / 500 m
	Mini prism (GMP101):	500 m / 400 m
	Reflective tape (60 mm x 60 mm):	55 m (175 ft)
	Shortest measurable distance:	1.5 m / 5 m
Accuracy / Measure time	ATR angle accuracy Hz, V:	1 " (0.3 mgon)
(std. dev. ISO 17123-3)	Base positioning accuracy:	± 1mm
	Measure time for GPR1:	3 – 4 s
Maximum speed (LOCK mode)	Tangential (standard mode):	5 m / s at 20 m, 25 m / s at 100 m
	Radial (tracking mode):	4 m / s
Method	Digital image processing (laser beam)	

PowerSearch (PS)

Range	Round prism (GPR1):	300 m
(average atmospheric conditions)	360° reflector (GRZ4, GRZ122):	300 m (perfectly aligned to instrument)
	Mini prism (GMP101):	100 m
	Shortest distance:	5 m
Search time	Typical search time:	< 10 s
Maximum speed	Rotating speed:	45° / s
Method	Digital signal processing (rotating laser fan)	

Guide Light (EGL)

Range		
(average atmospheric conditions)	Working range:	5 m – 150 m
Accuracy	Positioning accuracy:	5 cm at 100 m

General data

Telescope	
Magnification:	30 x
Free objective aperture:	40 mm
Field of view:	1°30′ (1.66 gon) / 2.7 m at 100 m
Focusing range:	1.7 m to infinity

Keyboard and Display	
Display:	1/4 VGA (320*240 pixels), graphic LCD, colour, illumination, touch screen
Keyboard:	34 keys (12 function keys, 12 alphanumeric keys), illumination
Angle display:	360° ' '', 360° decimal, 400 gon, 6400 mil, V%
Distance display:	meter, int. ft, int. ft/inch, US ft, US ft/inch
Position:	face I standard / face II optional

Data storage	
Internal memory:	256 MB (optional)
Memory card:	CompactFlash cards (256 MB)
Number of data records:	1750 / MB
Interfaces:	RS232, *Bluetooth*® Wireless-Technology (optional)

Circular Level	
Sensitivity:	6' / 2 mm

Laser plummet	
Centering accuracy:	1.5 mm at 1.5 m
Laser dot diameter:	2.5 mm at 1.5 m

Endless drives	
Number of drives:	1 horizontal / 1 vertical

Battery (GEB221)	
Type:	Lithium-Ion
Voltage:	7.4 V
Capacity:	4.4 Ah
Operating time:	typ. 5 – 8 h

Weights	
Total station:	4.8 – 5.5 kg
Battery (GEB221):	0.2 kg
Tribrach (GDF121):	0.8 kg

Environmental specifications	
Working temperature range:	−20° C to +50° C
Storage temperature range:	−40° C to +70° C
Dust / water (IEC 60529):	IP54
Humidity:	95 %, non-condensing

Remote Control Unit (RX1250T/Tc)

Communication	via integrated radio modem	
Control unit	Display:	1/4 VGA (320*240 pixels), graphic LCD, touch screen, illumination
	Keyboard:	62 keys (12 function keys, 40 alphanumeric keys), illumination
	Interface:	RS232
Battery (GEB211)	Type:	Lithium-Ion
	Voltage:	7.4 V
	Capacity:	2.2 Ah
	Operating time:	RX1250T: typ. 9 h, RX1250Tc: typ. 8 h
Weights	Control unit RX1250T/Tc:	0.8 kg
	Battery (GEB211):	0.1 kg
	Reflector pole adapter:	0.25 kg
Environmental specifications	Working temperature range:	RX1250T −30° C to +65° C / RX1250Tc −30° C to +50° C
	Storage temperature range:	−40° C to +80° C
	Protection against water, dust and sand (IEC 60529, MIL-STD-810F)	IP67 waterproof to 1 m temporary submersion, dust tight